

Large UAS Operations in the NAS

The NASA 2007 Western States Fire Missions (WSFM)



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26th ICAS/8th ATIO
September 2008



Aircraft Systems

IKHANA

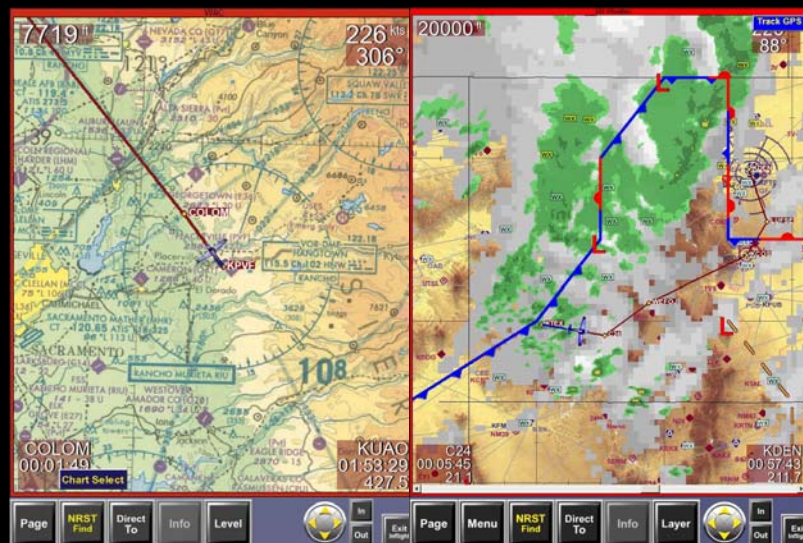


NASA Ames – Autonomous Modular Sensor (AMS)



Ground Systems

IKHANA



26th ICAS/8th ATIO, Large UAS in the NAS - NASA 2007 WSFM



2007 Western States Fire Mission Objectives

IKHANA

- Demonstrate capabilities of UAS to overfly and collect sensor data on wildfires throughout Western US.
- Demonstrate long-endurance mission capabilities (20+ hours).
- Image multiple fires (greater than 4 fires per mission), to showcase extendable mission configuration and ability to either linger over key fires or station over disparate regional fires.
- Deliver real-time imagery to (within 10-minutes of acquisition).



Certificate of Authorization (COA) Boundary Request

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3 Operational Zones

Each zone includes no more than 3 FAA ARTCC areas

**All, or parts of:
California, Nevada,
Oregon, Washington,
Utah, Montana,
Wyoming, Idaho,
Colorado, Arizona,
New Mexico**






Range Safety Protection Zones

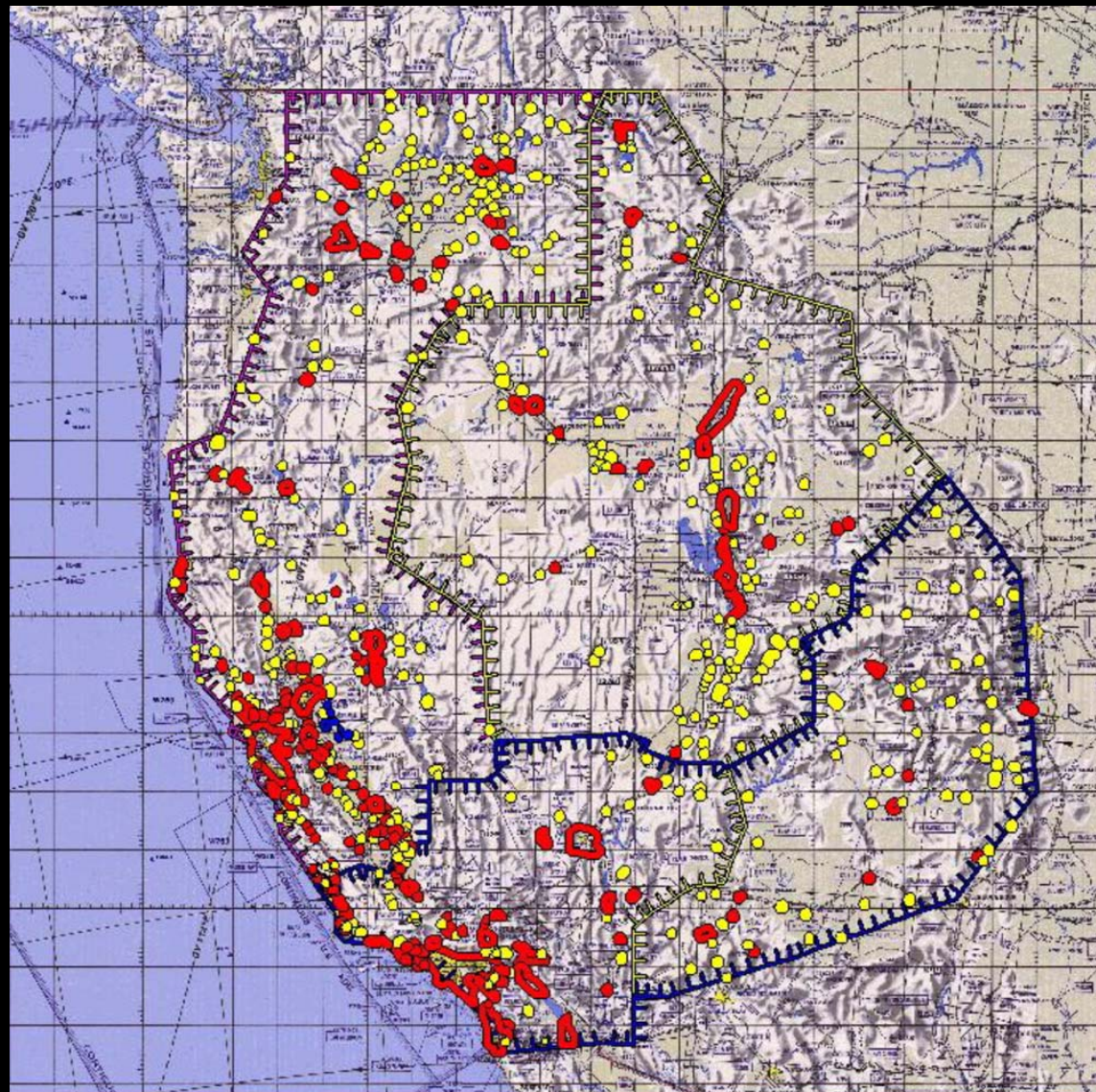
IKHANA

KEEP-OUT ZONES

Defined and “Owned”
by DFRC Range Safety

Can be changed or
updated before or
during flight with DFRC
Range Safety
concurrence

-  **NOMINAL
AIRCRAFT**
-  **UNHEALTHY
AIRCRAFT**





Routes A, B, C

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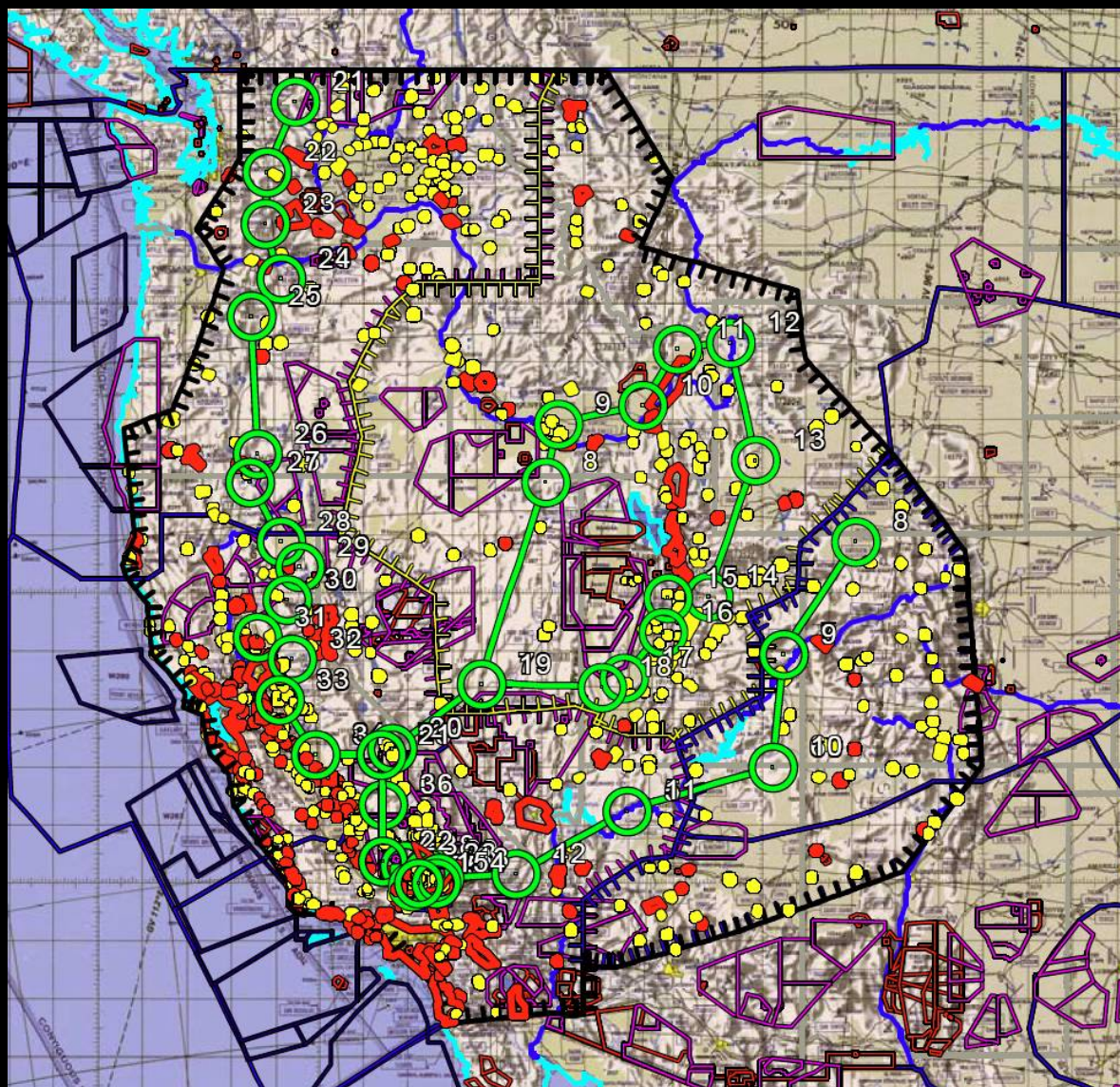
Defined Routes for each Zone

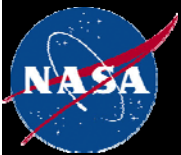
Over/near forested areas

Avoid population areas

Avoid directly above mountains when possible

- Weather when lost link





Primary Emergency Landing Sites

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Radius = 400 nm

Landing
agreements
negotiated with
each site





Secondary Emergency Landing Sites

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Radius = 50 nm

Over 280 sites identified

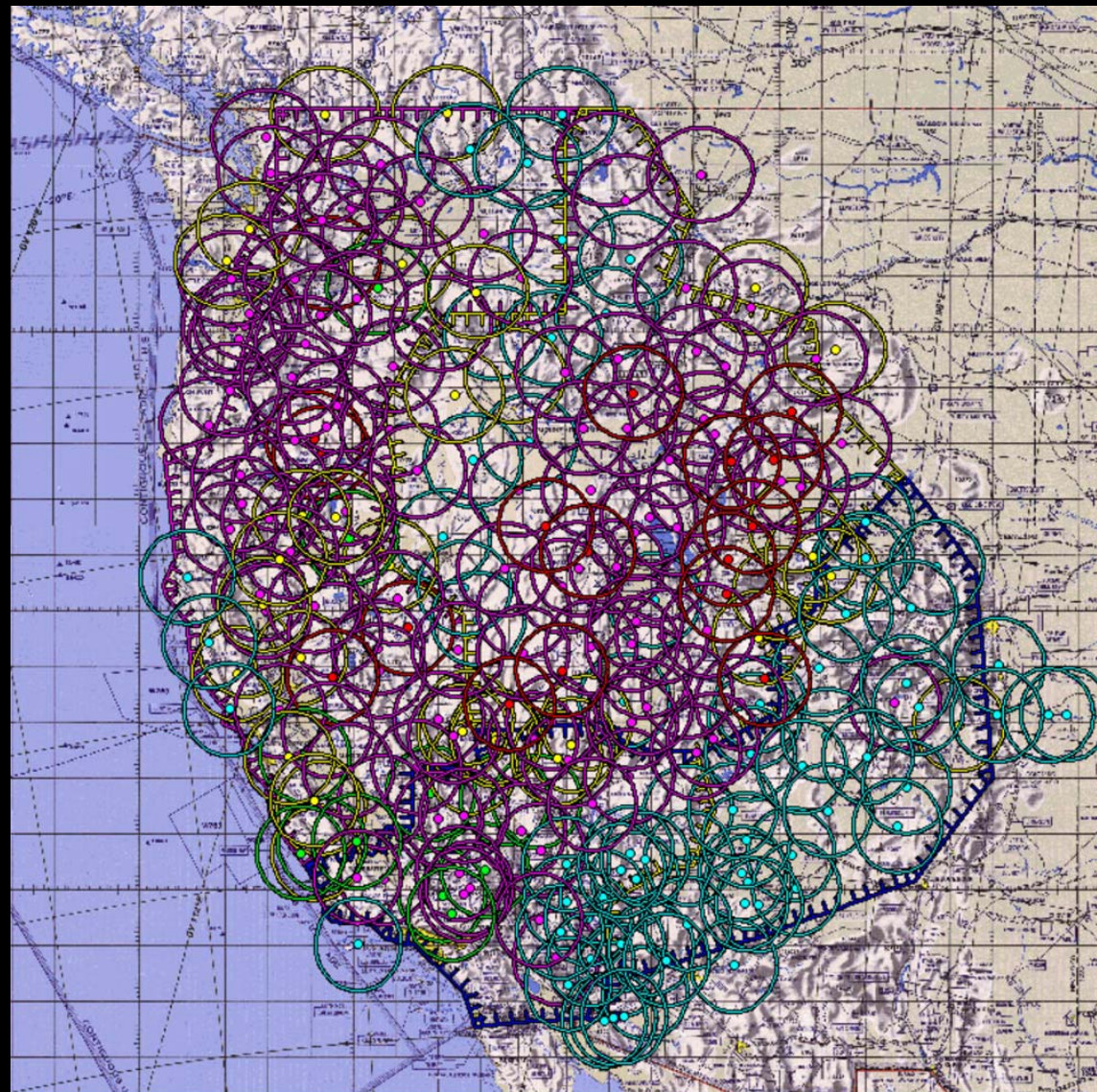
**Categorized Green, Yellow,
Purple, Red by pilots**

**Selected in unpopulated
areas. Abandoned runways,
dry lakebeds, flat ground,
ditch areas**

**Primary purpose is to
protect public**

**Actively managed during
each mission**

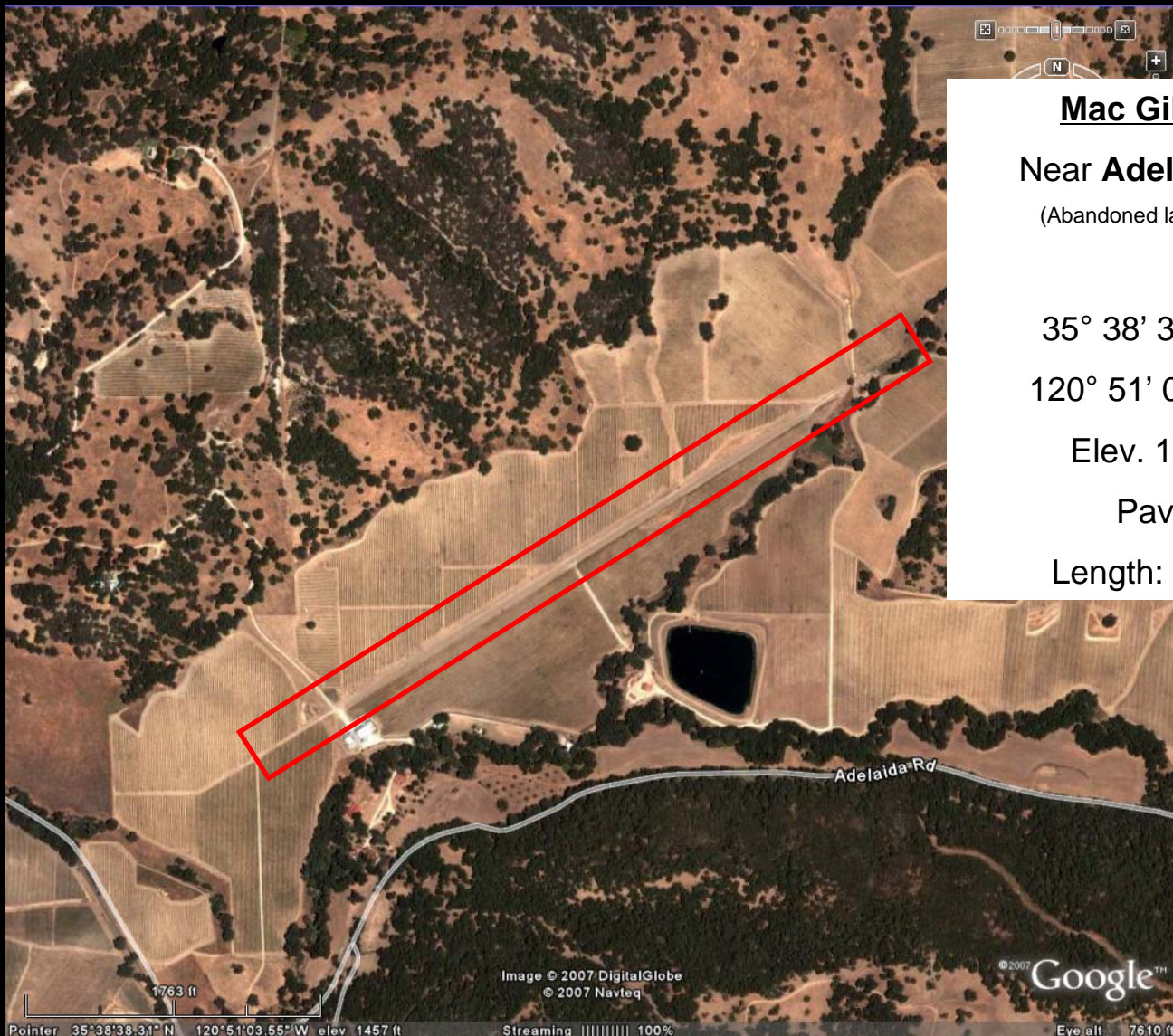
**“Owned” by DFRC Range
Safety and changeable**





Secondary Emergency Landing Site – Example 1

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Mac Gillivray

Near **Adelaida, CA**

(Abandoned landing strip)

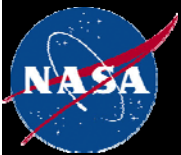
35° 38' 39.52" N

120° 51' 01.37" W

Elev. 1454 ft

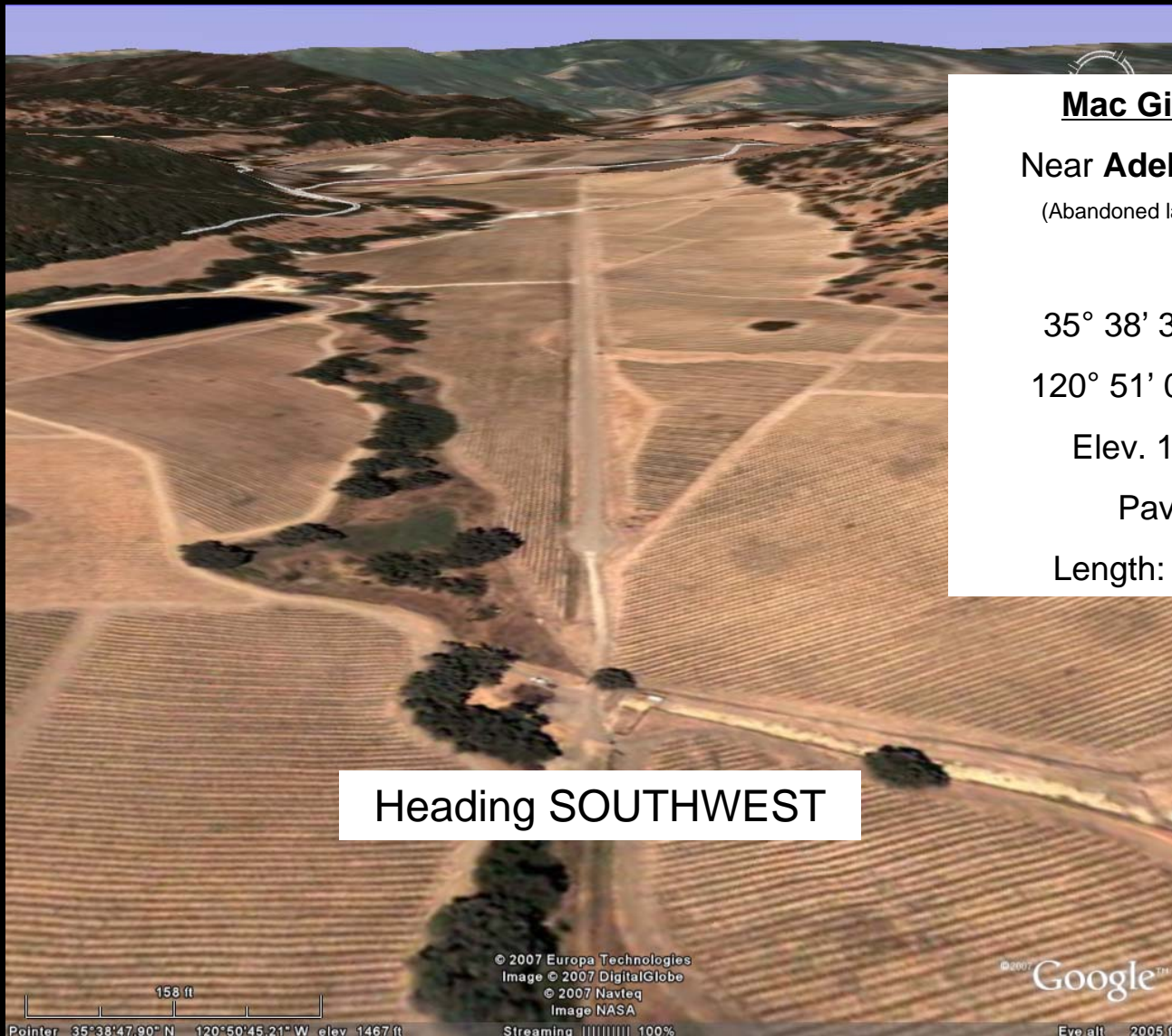
Paved

Length: 3000 ft



Secondary Emergency Landing Site – Example 2

IKHANA



Mac Gillivray

Near Adelaida, CA

(Abandoned landing strip)

35° 38' 39.52" N

120° 51' 01.37" W

Elev. 1454 ft

Paved

Length: 3000 ft

Heading SOUTHWEST

© 2007 Europa Technologies
Image © 2007 DigitalGlobe
© 2007 Navteq
Image NASA

Google™

Pointer 35°38'47.90" N 120°50'45.21" W elev. 1467 ft

Streaming 100%

Eve.alt 2005 ft

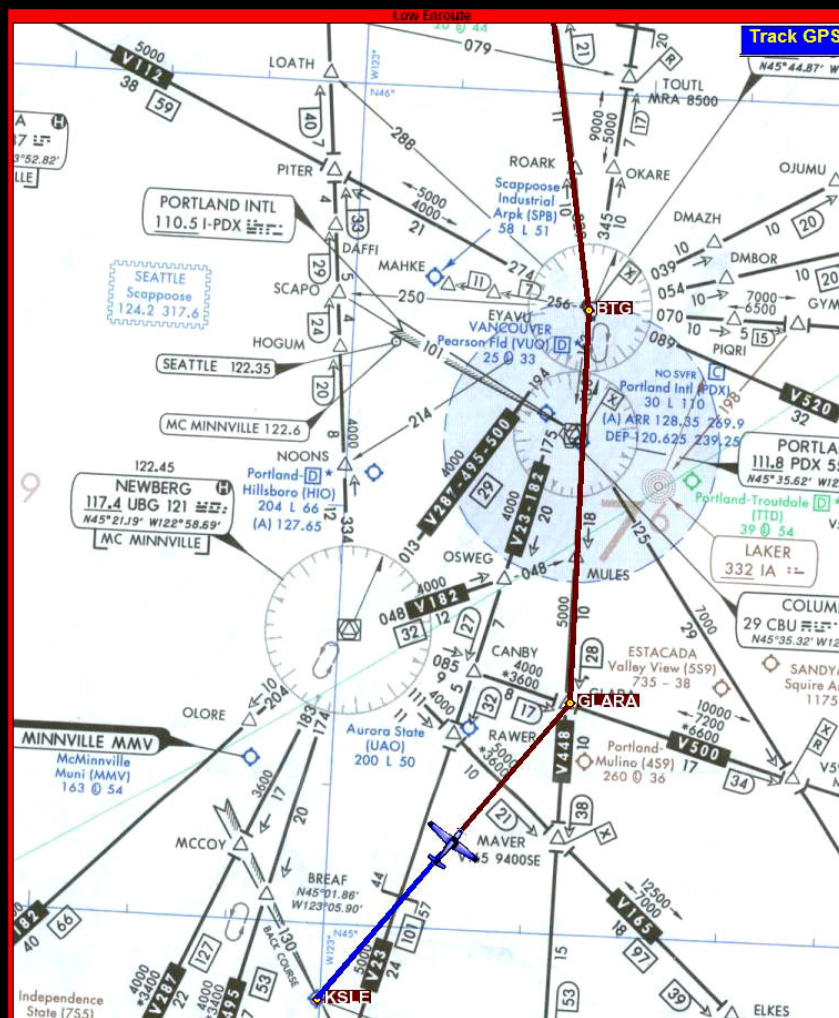


EFB: ChartCase Professional™

IKHANA



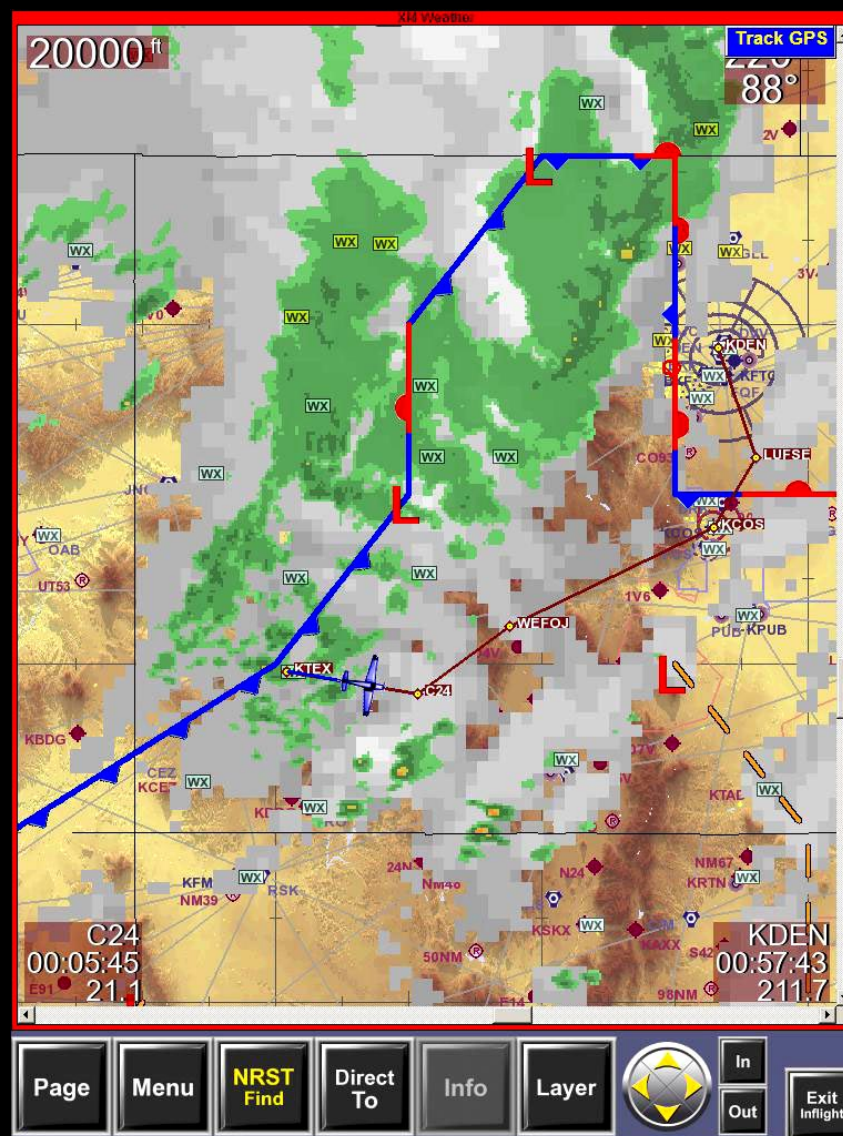
Page NRST Find Direct To Info Level In Out Exit Inflight



Page Menu NRST Find Direct To Info Layer In Out Exit Inflight



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COA Application Provisions

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- Only for “4-5” flights, 1 per week
 - But... wildfire emergencies could occur that would require quick turnaround and possibly more flights
- Stay 5 nm away from Zone boundaries
- Stay 10 nm away from International borders
 - Canada, Mexico
- Public Use aircraft
- NASA self-certifies for airworthiness



COA: Special Provisions

IKHANA

- Remain within 75 nm of 'backbone' route
- 3 business day mission notification to FAA
 - With "specific routes" identified
- IFR Flight Plan submitted 24 hours in advance
- Flight Plan
 - Point to point is acceptable
 - in FRD format (fix-radial-distance)
 - No more than 48 elements (fixes + loiter times)
- Mission Planning telecon with affected ATC Centers 24 hours prior to mission



COA: Special Provisions (con't)

IKHANA

- No flight into forecasted “moderate or severe” turbulence
- No flight in area where convective SIGMET has been issued
- No flight in area of known or forecast icing
- No flight in area of affected by GPS testing, solar storms or RAIM outages
- Contact list maintained for all ATC Centers and Ikhana GCS



COA: Special Provisions (con't)

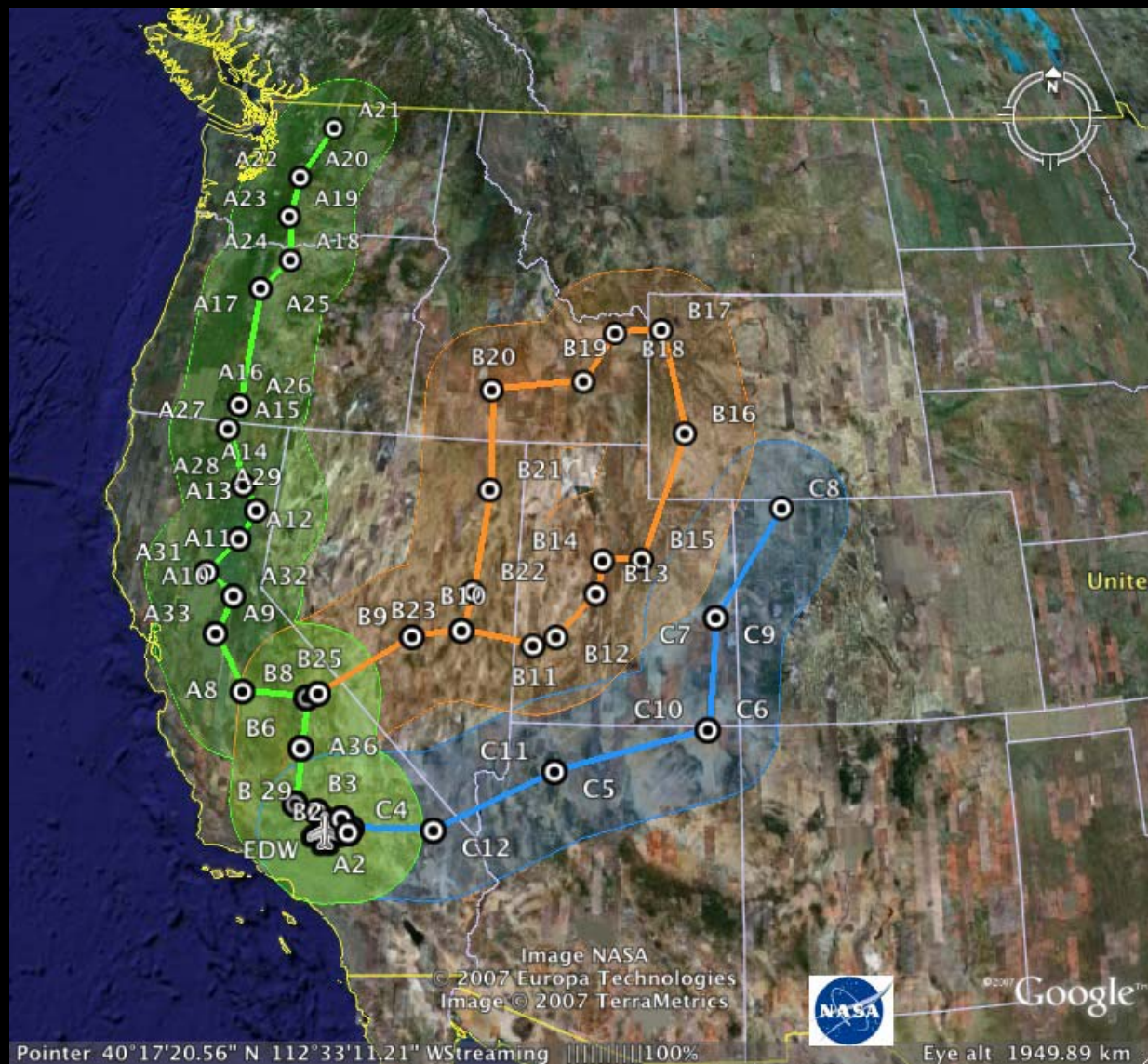
IKHANA

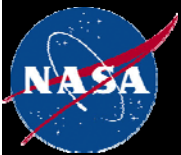
- Lost link procedure
 - Maintain altitude
 - Continue on filed flight plan (the route) for 15 min
 - Does not mean “keep going straight ahead for 15 minutes”
 - If in a loiter area, stay in there for at least 15 minutes
 - Squawk 7600
 - Aircraft will turn right, if it has to retrace the flight plan
 - Aircraft will return to R-2508/R-2515 the way it came out (usually)



Approved COA Area

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WSFM #1 - #4 Flight Tracks

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WSFM #3 9/7/07
20 hours
3200 nmi

WSFM #2
8/29/07
16.1 hours
2500 nmi

WSFM #1
8/16/07
9.5 hours
1400 nmi

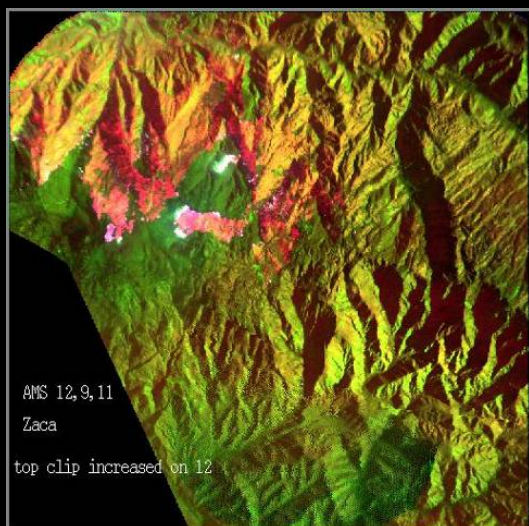
WSFM #4
9/27/07
10 hours
1800 nmi





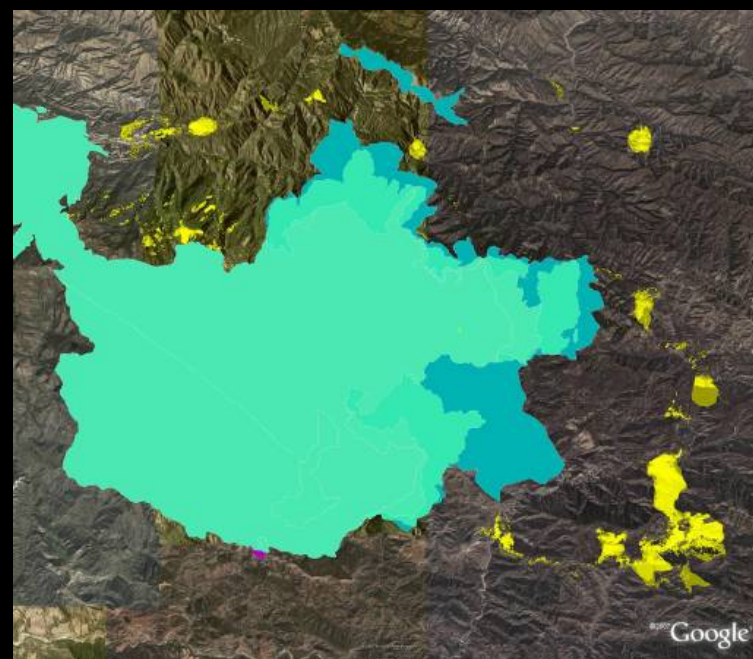
WSFM #1 – Aug. 16, Zaca Fire

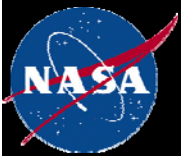
IKHANA



- Delivered near real-time data to the Incident Command Center for the Zaca fire

“ Our conversation surrounded the "fog of war" existing due to an inversion on the southeast corner of the fire... the incident management teams did not know where the fire was, and that information was critical to modify their strategy and initiate action. The intel provided by the UAV, real time and geospatially oriented, answered that critical question and saved precious hours. Yes, indeed, it was a success...”

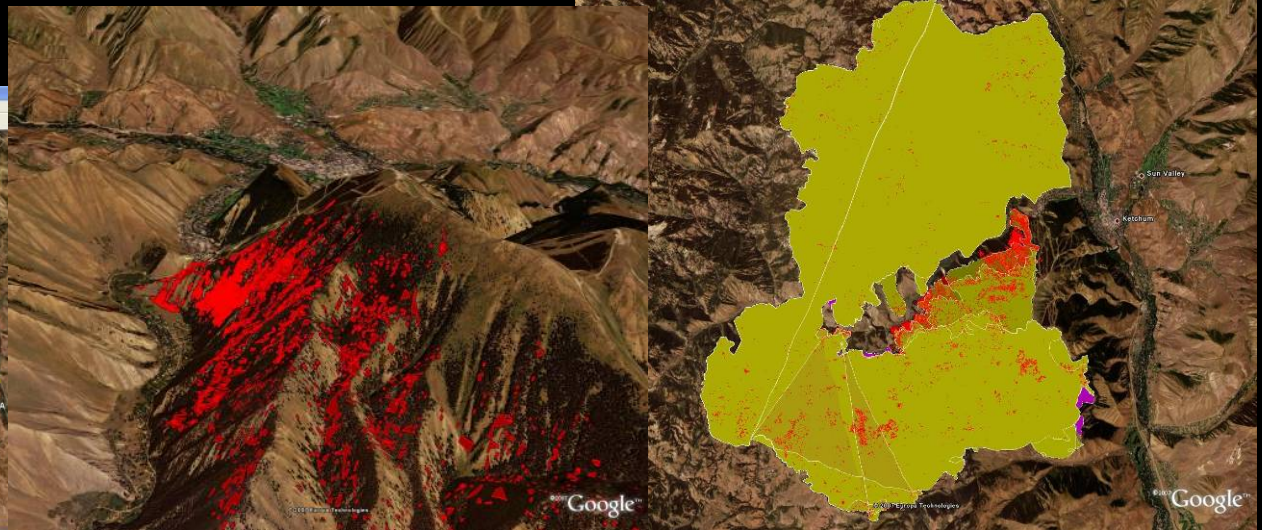
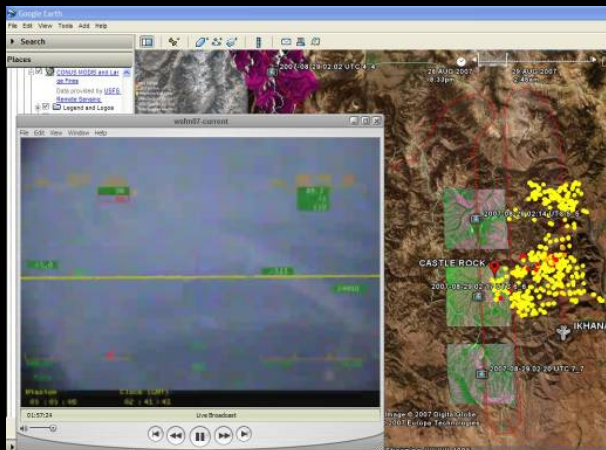
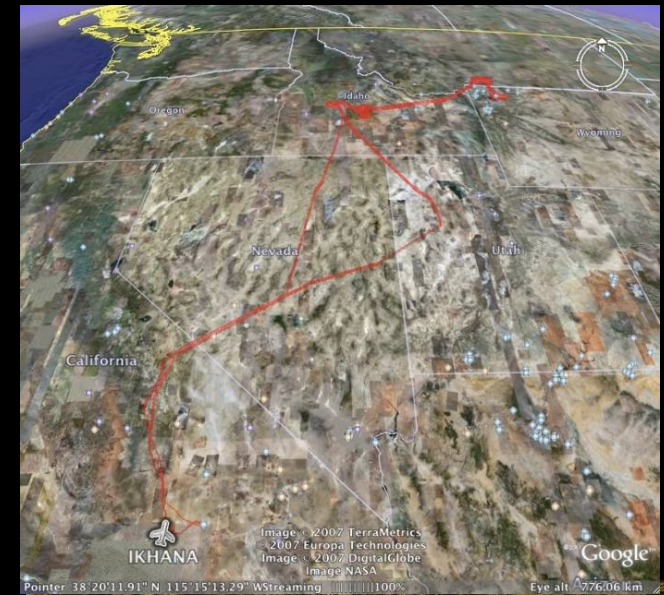




WSFM #2 – Aug. 29-30

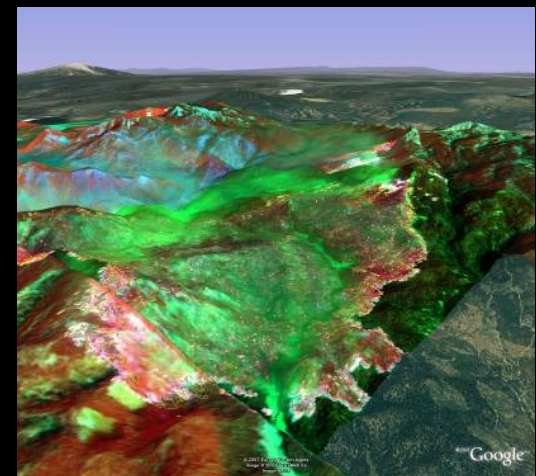
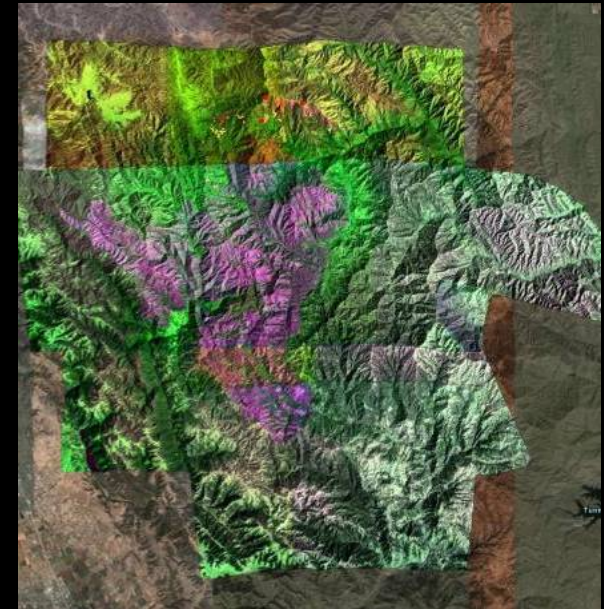
IKHANA

- Real-time ATC routing around poor weather saved the mission
- Collected and transmitted real-time fire data on eight fires spread through CA (Jackrabbit), ID (Trapper Ridge, Castle Rock, Granite Creek, and Hardscrabble), MT (WH Fire), and WY (Columbine Fire).
- Made repeat passes over each, spending most time over Castle Rock, as this was a high priority fire for US, threatening Ketchum and Sun Valley, ID.
- Delivered near real-time data to Incident Command on Castle Rock; used for operations and redeployment of resources on the fire based on the data.
- Collected coincident UAV data with a MODIS satellite data overpass on Castle Rock...major science accomplishment
- Tremendous amount of national publicity for NASA, USFS, and the FAA.





- Collected and transmitted near real-time fire data on eleven fires spread through CA (Butler, North, Fairmont, Grouse, Lick, Bald, Moonlight, Zaca), OR (GW & Big Basin Fires), and WA (Domke Lake and South Omak Fires),
- Made repeat passes over most, (total of 18 fire visits) spending significant time over high priority fires (Lick, Moonlight, and GW)

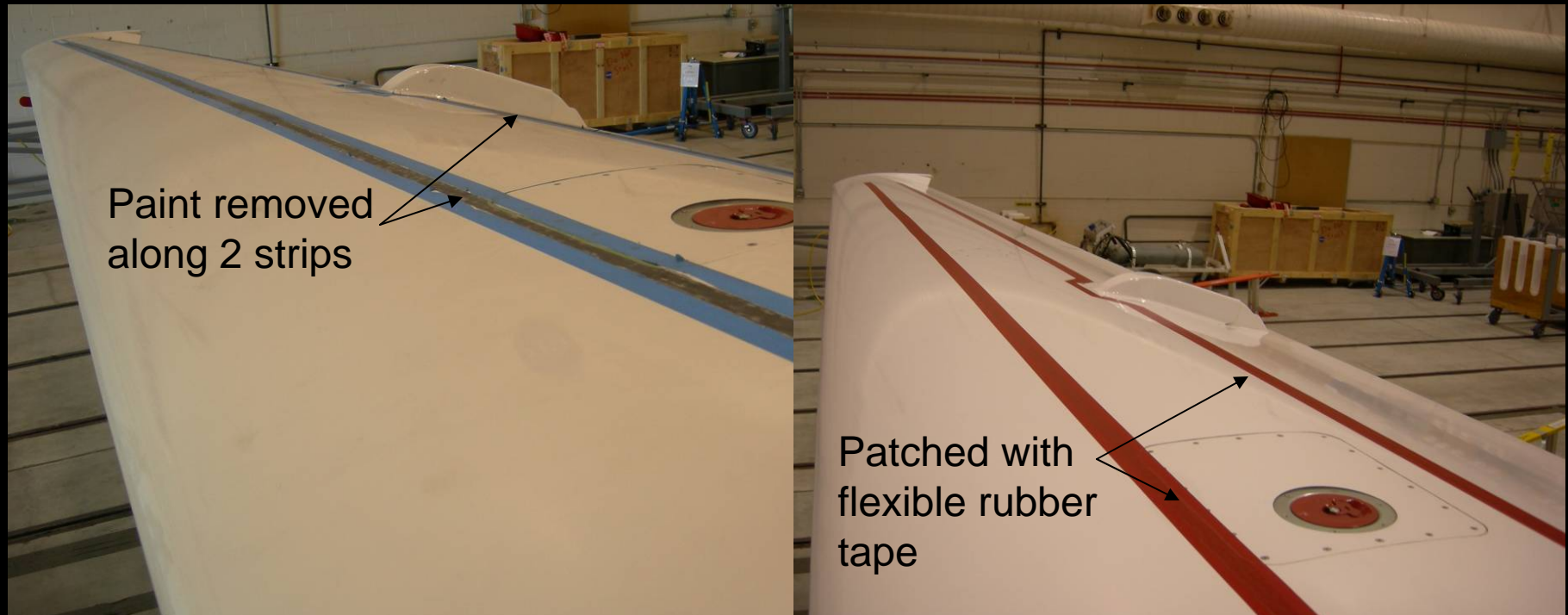




California Emergency Wildfire Response

IKHANA

- Oct 20-21: Wildfires start and spread in southern California
- Oct 22nd: Ikhana team began preparation for a possible fire mission
 - Two impediments
 - Failed hard drive in the wildfire sensor
 - Ikhana wings being modified for another experiment.
- Oct 24th: 1st Emergency response mission (WSFM #5)

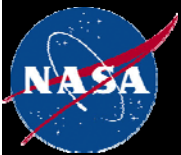




WSFM #5 - #8 Flight Tracks

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WSFM #5 – Oct. 24th, Ammo Fire

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Hot spots in yellow



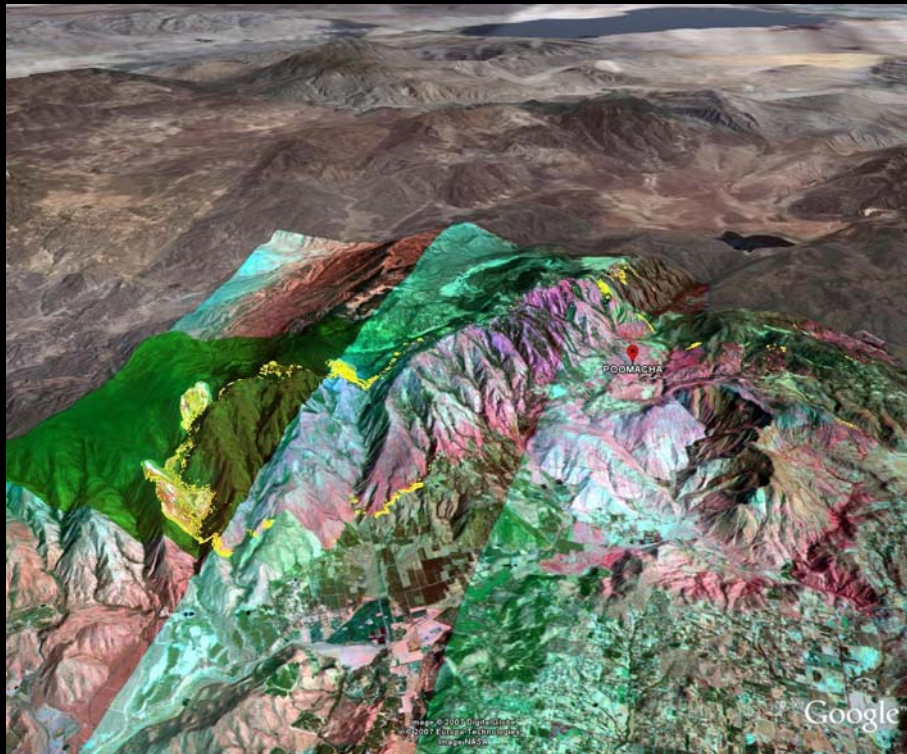


WSFM #6 - Oct. 25th

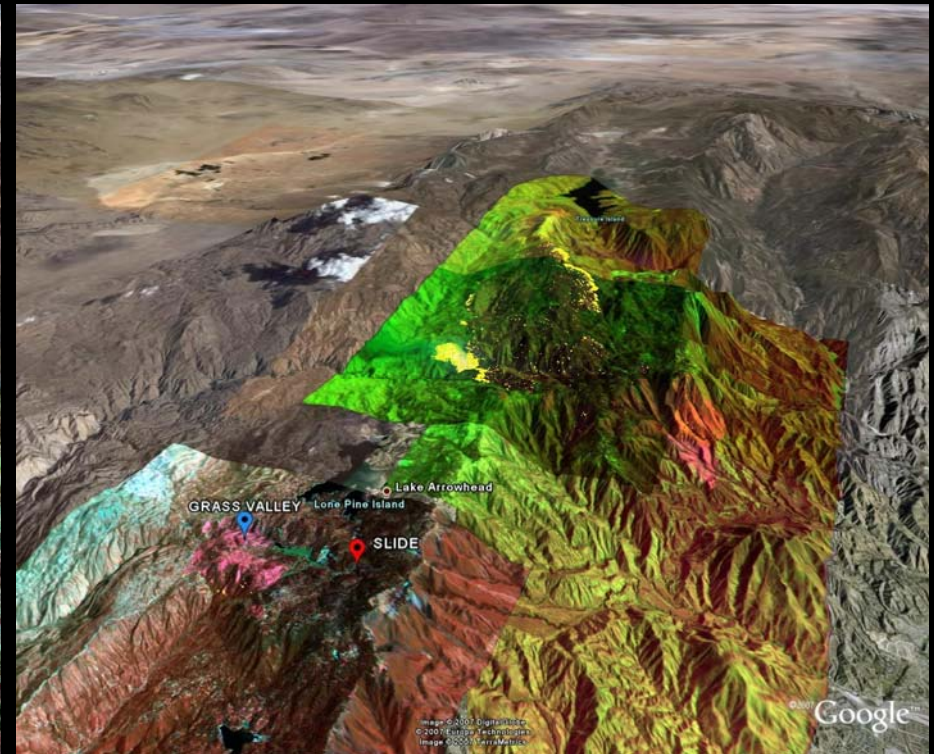
IKHANA

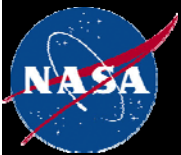
Hot spots in yellow

Poomacha / Rice Fires – 3D with Hot Detects



Grass Valley / Slide Fires - 3D with Hot Detects



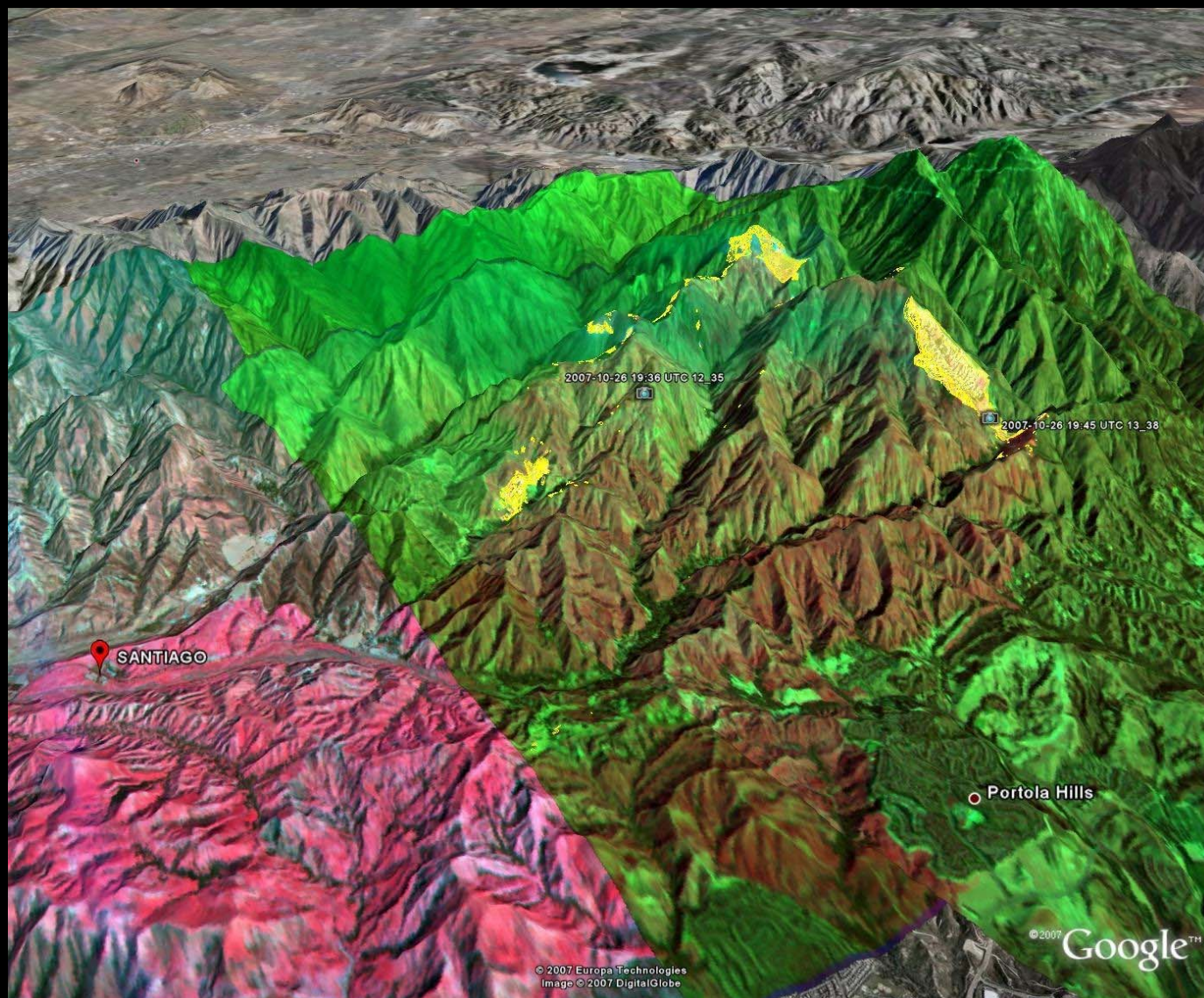


WSFM #7 - Oct. 26th

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Hot spots in yellow

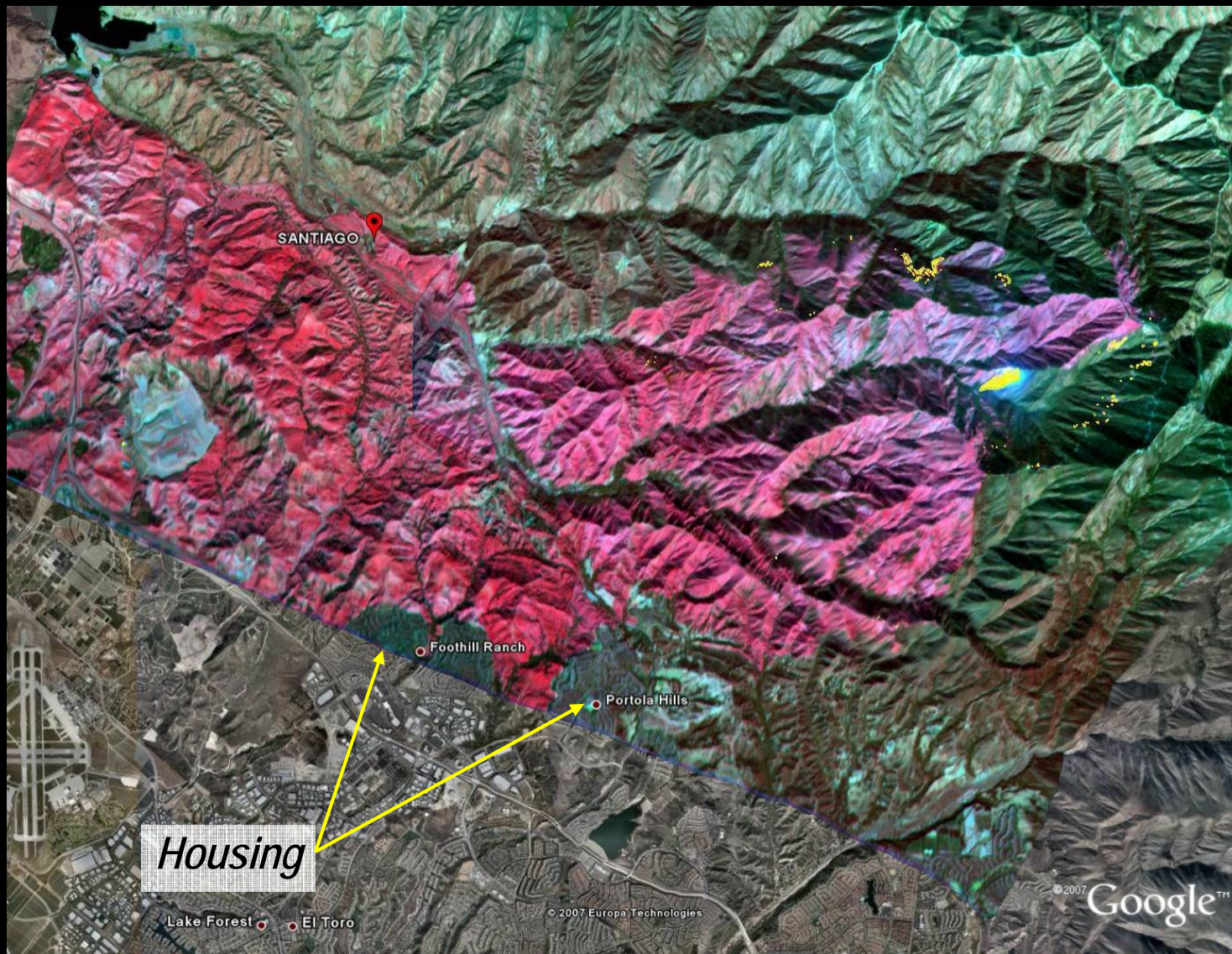
**Santiago Fire –
3D with Hot Detects**





WSFM #8 - Oct. 28th, Santiago Fire

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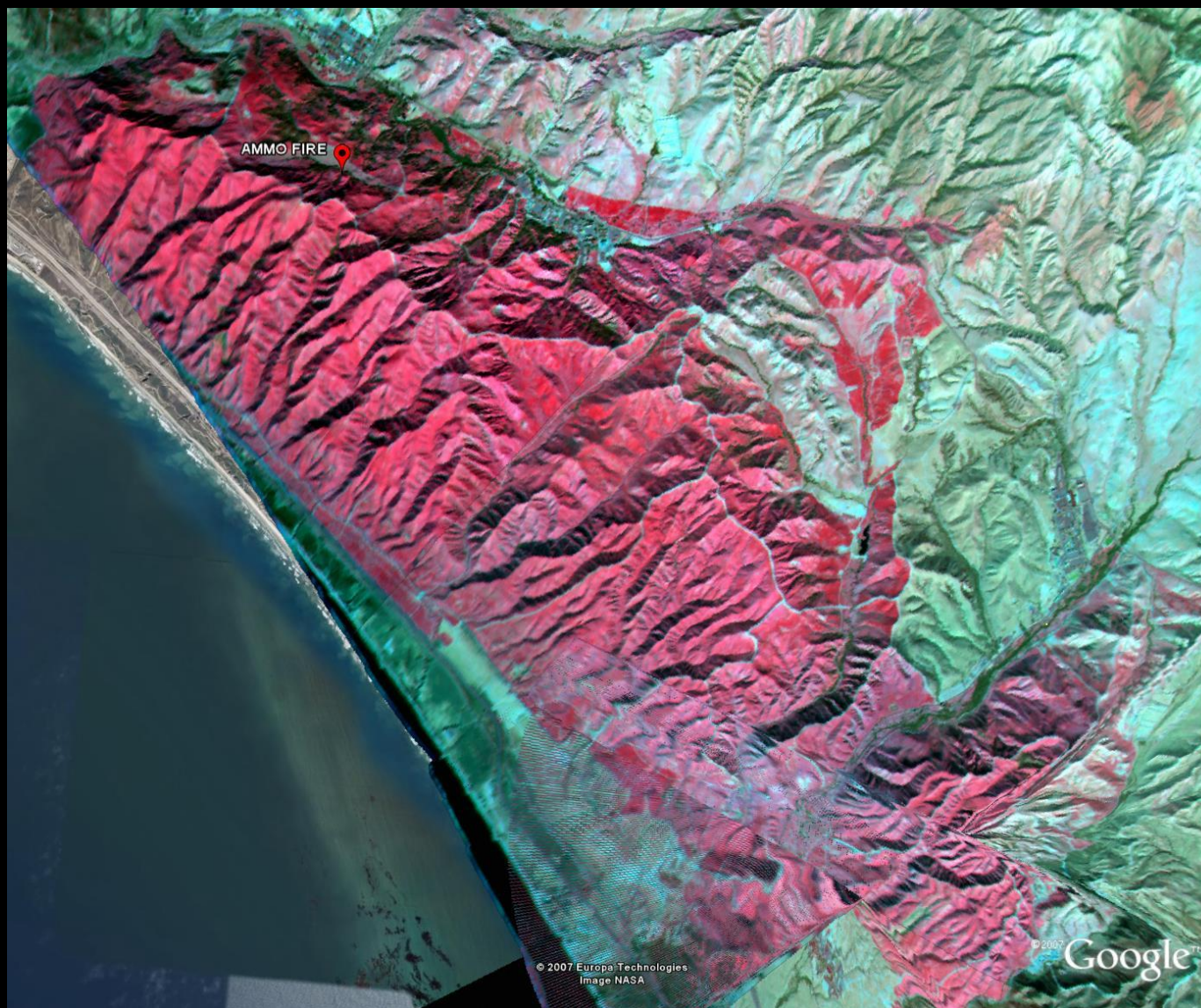




WSFM #8 - Oct. 28th, Ammo Burn Area

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*Sensor optimized
for Burn Area
Emergency
Response (BAER)
imagery*



26th ICAS/8th ATIO, Large UAS in the NAS - NASA 2007 WSFM



WSFM #5 - #8 Southern California Results

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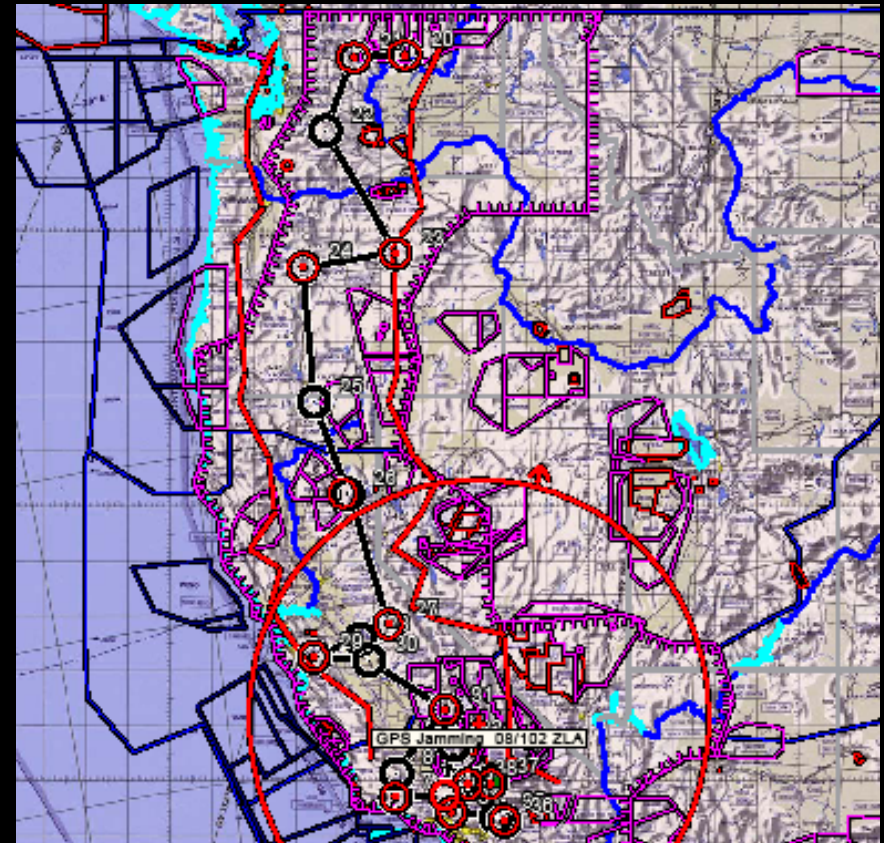
- Four 9-hr missions flown
 - 5 day period covering Wednesday, Thursday, Friday, Sunday
 - Post flight debrief with DFRC team
 - Post flight/preflight brief with FAA HQ and LA Center
- Air Traffic Control gave excellent support
 - Mission plans flown in reverse
 - Real time requests for revisits of active fires
 - Added new fire during mission
 - Moved fire loiter points as fires moved
- Thermal infrared imagery delivered in near real-time (5 to 15 minutes)
 - FEMA, NIFC, California EOC
 - Individual Fire Incident Command Centers
- Ventura County Fire Chief reported:
 - “Intel” was used tactically to fight the fires
 - “Intel” was used strategically to prioritize fires and allocate resources between fires
 - “Intel” was used to allow some fires to burn into each other



2007 WSFM Challenges

IKHANA

- GPS Testing – 250+ nm RADIUS
- Command/Control frequency access
- Emergency landing site permission
- Weather
 - Wind
 - Clouds
 - Icing
 - Thunderstorms
- Long missions

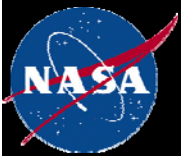




Credit where Credit is Due

IKHANA

- THE FAA HQ UAPO (UAS) Office
 - Not possible without GREAT cooperation and communication
- FAA ATC Centers and Controllers
 - Los Angeles, Oakland, Seattle, Salt Lake, Albuquerque, Denver
- USAF
- DFRC Range Safety Office (RSO)
- General Atomics



Questions?

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